CHAPTER

1

THE NEED FOR INTEGRATED STORM WATER MANAGEMENT

1.1 Impacts of Development and Storm Water Runoff

Land development changes not only the physical conditions, but can also change the chemical and biological conditions of streams, lakes and other receiving waters. This chapter describes the changes in our local receiving waters that can occur due to development and storm water runoff, and the potential impacts.

1.1.1 Development Changes Land and Runoff

When land is developed the natural water cycle is altered. Clearing removes the vegetation that intercepts, slows and returns rainfall to the air through evaporation and transpiration. Grading flattens terrain and fills in natural depressions that slow and provide temporary storage for rainfall. The topsoil and sponge-like layers of humus are scraped and the remaining subsoil is compacted. Rainfall that once seeped into the ground is made to run off the surface. The addition of buildings, roadways, parking lots and other impervious surfaces further reduces infiltration and increases runoff. Figure 1-1 is an example of the changes that take place as land is developed.

Figure 1-1 Typical Changes in Land Surface for a Commercial Site

Depending on the magnitude of changes to the land surface, the percentage of rainfall that becomes storm water runoff can increase dramatically. These changes not only increase storm water runoff, but also accelerate the rate at which runoff flows across the land. This effect is further exacerbated by drainage systems such as gutters, storm sewers and lined channels that are designed to quickly carry runoff to rivers and streams. Development and impervious surfaces also reduce the amount of water that infiltrates into the soil and groundwater, thus reducing the amount of water that recharges aquifers and feeds stream flow during periods of dry weather. The changes in hydrology and runoff that can result from land development are illustrated in Figure 1-2.

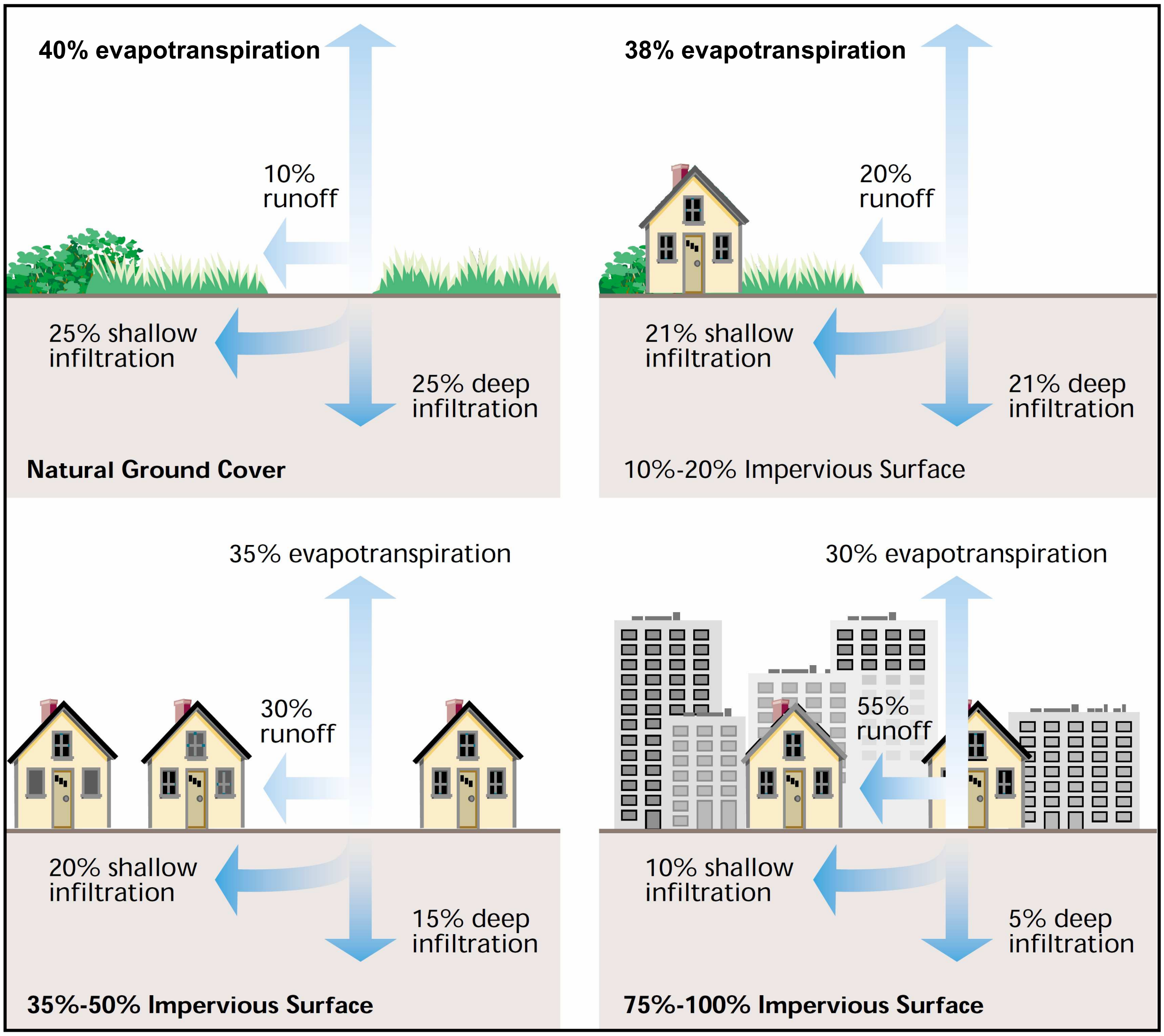

Figure 1-2 Changes in Hydrology and Runoff Due to Development
Adapted from "Stream Corridor Restoration: Principles, Processes, and Practices, 10/98, by the FISRWG."

Finally, development and urbanization affect not only the quantity of storm water runoff, but also its quality. Development can increase both the concentration and types of pollutants carried by runoff. As it runs over rooftops and lawns, parking lots and commercial sites, storm water picks up and transports a variety of pollutants to downstream waterbodies. The loss of the original topsoil and vegetation removes a valuable filtering mechanism for storm water runoff.

Figure 1-3 Impervious Cover Increases Storm Water Runoff and Transports Pollutants to Local Waterways

The cumulative impact of development and urban activities, and the resultant changes to both storm water quantity and quality in the land area that drains to a stream, river, or lake determines the conditions of the waterbody. This land area that drains to the waterbody is known as its watershed. Urban development within a watershed has a direct impact on downstream waters. The impacts of development on watersheds can be placed into four interrelated categories which are described over the next several pages:

- changes to stream flow;
- changes to stream geometry;
- degradation of aquatic habitat; and,
- water quality impacts.

1.1.2 Changes to Stream Flow

Urban development alters the hydrology of watersheds and streams by disrupting the water cycle that existed prior to development. This results in:

- Increased Runoff Volumes: Land surface changes can dramatically increase the total volume of runoff generated in a developed watershed.
- Increased Peak Runoff Discharges: Increased peak discharges for a developed watershed can be much greater than those for an undisturbed watershed.
- Greater Runoff Velocities: Impervious surfaces and compacted soils, as well as improvements to the drainage system such as storm drains, pipes and ditches, increase the speed at which rainfall runs off land surfaces within a watershed.
- Timing: As runoff velocities increase, it takes less time for water to run off the land and reach a stream or other waterbody. This changes the timing of flows downstream, which can lead to increased flooding.
- Increased Frequency of Bankfull and Near Bankfull Events: Increased runoff volumes and peak flows increase the frequency and duration of smaller bankfull and near bankfull events. Bankfull indicates the stage of the stream that just fills the channel. These medium-sized storms are the primary channel-forming events.
- Increased Flooding: Increased runoff volumes and peaks also increase the frequency, duration and severity of out-of-bank flooding.
- Lower Dry Weather Flows (Baseflow): Reduced infiltration of storm water runoff reduces the amount of rainfall recharging groundwater and may cause streams to have less baseflow during dry weather periods.

Figure 1-4 Increased Runoff Peaks and Volumes Increase Stream Flows and Flooding
Main Street during 1904 flood and Hyatt building as seen from the Lewis Street bridge during 1998 flood

Streams in developed areas are often characterized as "flashy" because of the increased volume of storm water runoff, greater peak flows, and quicker hydrologic response to storms. This characterization translates into increased size of the unregulated post-development hydrograph as illustrated in Figure 1-5. This diagram shows the hydrograph for a typical 30-acre residential site during a 10-year storm event.

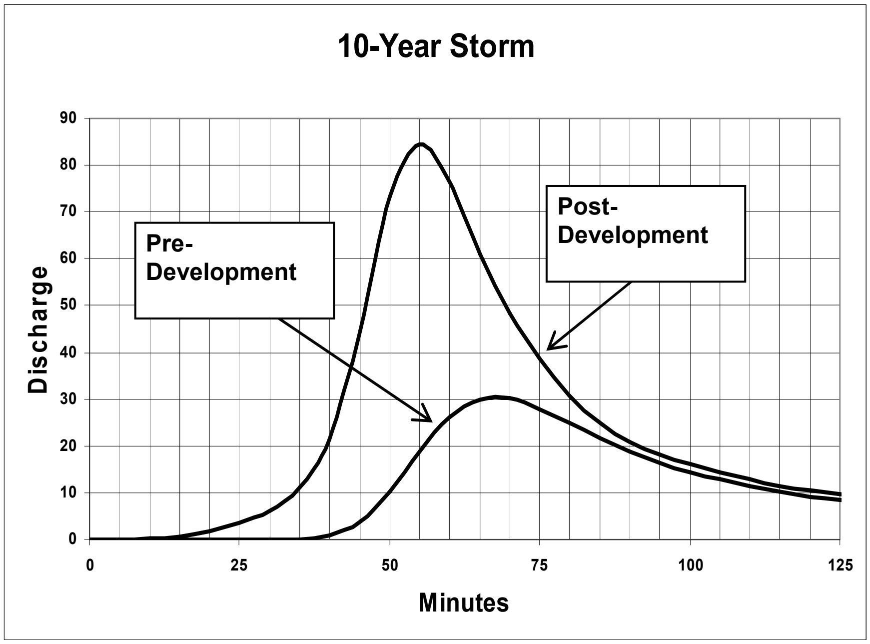

Figure 1-5 Hydrograph under Pre- and Post Development Conditions

1.1.3 Changes to Stream Geometry

Changes in the rates and amounts of runoff from developed watersheds directly affect the morphology, or physical shape and character, of streams and rivers. An example of the progression of the impacts due to urban development is shown in Figure 1-6.

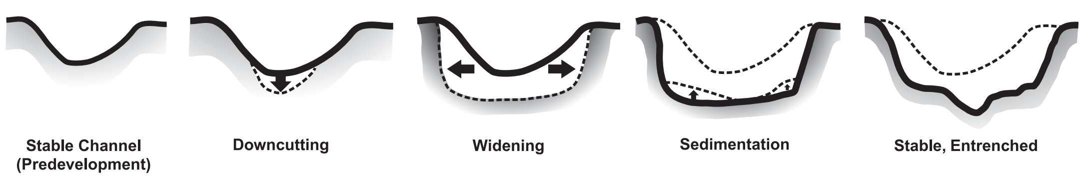

Figure 1-6 Changes to a Stream's Physical Character Due to Urban Development

These urban impacts are described as follows:

- Stream Widening and Bank Erosion: Stream channels widen to accommodate and convey the increased runoff and higher stream flows from developed areas. Frequent small and moderate runoff events undercut and scour the lower parts of the streambank, causing the steeper banks to slump and collapse during larger storms. Higher flow velocities further increase streambank erosion rates. A stream can widen to many times its original size due to increased post-development runoff.
- Stream Downcutting: Another way that streams accommodate higher flows is by down-cutting their streambed. This may cause instability in the stream profile, triggering further channel erosion both upstream and downstream.

- Loss of Riparian Tree Canopy: As streambanks are gradually undercut and slump into the channel, the trees that may be protecting the banks are exposed at the roots. This leaves them more likely to be uprooted during major storms, further weakening bank structure.
- Changes in the Channel Bed Due to Sedimentation: Due to channel erosion (Figure 1-7) and other sources upstream, sediments may be deposited in the stream as sandbars and other features, covering the channel bed, or substrate, with shifting deposits of mud, silt and sand.
- Increase in the Floodplain Elevation: To accommodate the higher peak flow rate, a stream's floodplain elevation typically increases following development in a watershed due to higher peak flows. This problem can be compounded by building and filling in floodplain areas, which cause flood heights to rise even further. Property and structures that had not previously been subject to flooding may now be at risk.

Figure 1-7 Example of Stream Channel Bank Erosion
Photo courtesy of Kansas State Conservation Commission

1.1.4 Degradation of Aquatic Habitat

Along with changes in stream hydrology and morphology, the habitat value of streams diminishes due to development in a watershed. Impacts on habitat may include:

- Degradation of Habitat Structure: Higher and faster flows due to development can scour channels and wash away entire biological communities. Streambank erosion and the loss of riparian vegetation reduce habitat for many fish species and other aquatic life, while sediment deposits can smother bottom-dwelling organisms and aquatic habitat.

- Loss of Pool-Riffle Structure: Streams draining undeveloped watersheds often contain pools of deeper, more slowly flowing water that alternate with “riffles” or shoals of shallower, faster flowing water. These pools and riffles provide valuable habitat for fish and aquatic insects. As a result of the increased flows and sediment loads from urban watersheds, the pools and riffles may disappear and be replaced with more uniform, and often shallower, streambeds that provide less varied aquatic habitat.
- Reduce Baseflows: Reduced baseflows due to increased impervious cover in a watershed and the loss of rainfall infiltration into the soil and water table adversely affect in-stream habitats, especially during periods of drought.
- Increased Stream Temperature: Runoff from warm impervious areas, storage in impoundments, loss of riparian vegetation and shallow channels can all cause an increase in temperature in urban streams. Increased temperatures can reduce dissolved oxygen levels and disrupt the food chain. Certain aquatic species can only survive within a narrow temperature range.
- Decline in Abundance and Biodiversity: When there is a reduction in various habitats and habitat quality, both the number and the variety, or diversity, of organisms (wetland plants, fish, macroinvertebrates, etc.) is also reduced. Sensitive fish species and other life forms disappear and are replaced by those organisms that are better adapted to the poorer conditions. The diversity and composition of the benthic, or streambed, community have frequently been used to evaluate the quality of urban streams. Aquatic insects are a useful environmental indicator as they form the base of the stream food chain.

Figure 1-8 Impacts to Aquatic Habitat
Litter and Sediments in Crystal Creek

Fish and other aquatic organisms are impacted not only by the habitat changes brought on by increased storm water runoff quantity, but are often also adversely affected by water quality changes due to development and resultant land use activities in a watershed. These impacts are discussed below.

1.1.5 Water Quality Impacts

Nonpoint source pollution, which is the primary cause of polluted storm water runoff and water quality impairment, comes from many diffuse or scattered sources—many of which are the result of human activities within a watershed. Development concentrates and increases the amount of these nonpoint source pollutants. As storm water runoff moves across the land surface, it picks up and carries away both natural and manmade pollutants, depositing them into streams, rivers, lakes, wetlands, marshes and aquifers.

Water quality degradation in urbanizing watersheds starts when development begins. Poorly controlled erosion from construction sites and other disturbed areas can contribute large amounts of sediment to streams. As construction and development proceed, impervious surfaces replace the natural land cover, and pollutants from human activities begin to accumulate on these surfaces. During storm events, these pollutants are then washed off into the streams. Discharges from sewer overflows and oveflows from septic tanks also contribute to the pollution load. There are a number of other causes of nonpoint source pollution in urban areas that are not specifically related to wet weather events including leaking sewer pipes, sanitary sewage spills, and illicit discharge of commercial/industrial wastewater and wash waters to storm drains.

Storm water runoff into lakes and reservoirs can have some unique negative effects. A notable impact of urban runoff can be the filling in of lakes and reservoirs with sediment. Another significant water quality impact on waterbodies related to storm water runoff is nutrient enrichment. This can result in the undesirable excessive growth of algae and aquatic plants. Lakes do not flush pollutants as quickly as streams and act as sinks for nutrients, metals and sediments. This means that lakes can take longer to recover from pollution.

Due to the magnitude of the problem, it is important to understand the nature and sources of urban storm water pollution. Table 1-1 summarizes the major storm water pollutants and their effects.

Table 1-1 Summary of Major Storm Water Pollutants

Constituents	Effects
Sediments—Suspended Solids, Dissolved Solids, Turbidity	Stream turbidity Habitat changes Recreation/aesthetic loss Contaminant transport Filling of lakes and reservoirs
Nutrients—Nitrate, Nitrite, Ammonia, Organic Nitrogen, Phosphate, Total Phosphorus	Algae blooms Eutrophication Ammonia and nitrate toxicity Recreation/aesthetic loss
Microbes—Total and Fecal Coliforms, Fecal Streptococci Viruses, E.Coli, Enterocci	Ear/Intestinal infections Recreation/aesthetic loss

Constituents	Effects
Organic Matter—Vegetation, Sewage, Other Oxygen Demanding Materials	Dissolved oxygen depletion Odors Fish kills
Toxic Pollutants—Heavy Metals (cadmium, copper, lead, zinc), Organics, Hydrocarbons, Pesticides/Herbicides	Toxicity to humans & aquatic organisms Bioaccumulation in the food chain
Thermal Pollution	Dissolved oxygen depletion Habitat degradation
Trash and debris	Recreation/aesthetic loss

Some of the most frequently occurring pollution impacts and their sources for urban streams are:

- <u>Reduced Oxygen in Streams:</u> The decomposition of organic matter uses up dissolved oxygen (DO) in the water, which is essential to fish and other aquatic life. As organic matter is washed off by storm water, dissolved oxygen levels in receiving waters can be rapidly depleted. If the DO deficit is severe enough, fish kills may occur and stream life can weaken and die. In addition, oxygen depletion can affect the release of toxic chemicals and nutrients from sediments deposited in a waterway. All forms of organic matter in urban storm water runoff such as leaves, grass clippings and pet waste contribute to the problem. In addition, non-storm water discharges of organic matter to surface waters, such as sanitary sewer leakage and septic tanks leaching, can also cause reduced oxygen levels.
- <u>Nutrient Enrichment:</u> Runoff from urban watersheds contains increased levels of nutrients such as nitrogen and phosphorus. Increased nutrient levels are a problem as they promote a condition known as eutrophication, which encourages excessive weed and algae growth in water bodies. An example of the eutrophication in the Dell is shown in Figure 1-9. Algae blooms block sunlight from reaching underwater grasses and deplete oxygen in bottom waters. In addition, nitrification of ammonia by microorganisms can consume dissolved oxygen, while nitrates can contaminate groundwater. Typical sources of nutrients in the urban environment include washoff of fertilizers and vegetative litter, animal wastes, sewer overflows and leaks, septic tank seepage, detergents, and the dry and wet fallout of materials in the atmosphere.

Figure 1-9 Eutrophication in the Dell

- Microbial Contamination: The level of bacteria, viruses and other microbes found in urban storm water runoff can exceed public health standards for water contact recreation such as swimming and wading. The main sources of these contaminants are sewer overflows, septic tanks, pet waste, and urban wildlife such as pigeons, waterfowl, squirrels and raccoons.
- Hydrocarbons: Oils, greases and gasoline contain a wide array of hydrocarbon compounds, some of which have been shown to be carcinogenic, tumorigenic and mutagenic in certain species of fish. In addition, large quantities of oil can impact drinking water supplies and affect recreational use of waters. Oils and other hydrocarbons are washed off roads and parking lots, primarily due to engine leakage from vehicles. Other sources include the improper disposal of motor oil in storm drains and streams, spills at fueling stations and restaurant grease traps.
- Toxic Materials: Besides oils and greases, urban storm water runoff can contain a wide variety of other toxicants and compounds including heavy metals such as lead, zinc, copper, and cadmium, and organic pollutants such as pesticides, PCBs and phenols. These contaminants are of concern because they are toxic to aquatic organisms and can bioaccumulate in the food chain. In addition, they may also impair drinking water sources and human health. Many of these toxicants accumulate in the sediments of streams and lakes. Sources of these contaminants include industrial and commercial sites, urban surfaces such as rooftops and painted areas, vehicles and other machinery, improperly disposed household chemicals, landfills, hazardous waste sites and atmospheric deposition.
- Sedimentation: Eroded soils are a common component of urban storm water and are a pollutant in their own right. Excessive sediment can be detrimental to aquatic life by interfering with photosynthesis, respiration, growth and reproduction. Sediment particles transport other pollutants that are attached to their surfaces including nutrients, trace metals and hydrocarbons. High turbidity due to sediment may increase the cost of treating drinking water and reduce the value of surface waters for industrial and recreational use. Sediment also fills ditches and small streams and clogs storm sewers

and pipes, and can cause flooding and property damage. Sedimentation can reduce the capacity of channels, reservoirs and lakes. Erosion from construction sites, exposed soils, street runoff, agriculture and streambanks are the primary sources of sediment in urban runoff.

- Higher Water Temperatures: As runoff flows over impervious surfaces such as asphalt and concrete, it may increase in temperature before reaching a stream or reservoir. Water temperatures are also increased due to shallow ponds and impoundments along a watercourse as well as the reduction of trees along streams, which provide shade to the stream. Since warm water can hold less dissolved oxygen than cold water, this "thermal pollution" further reduces oxygen levels in depleted urban streams. Temperature changes can severely disrupt aquatic species that can survive only within a narrow temperature range.
- Trash and Debris: Considerable quantities of trash and other debris are washed into gutters, down banks, and through storm drain systems into water bodies. Debris can cause blockage of a channel, which can result in localized flooding and erosion as shown in Figure 1-10. The debris blocking flow under the Harry Street Bridge contributed to the flooding of Harry Street.

Figure 1-10 Trash and Debris at a Bridge
Harry Street Bridge

1.1.6 Storm Water Hotspots

Storm water hotspots are areas of the urban landscape that often produce higher concentrations of certain pollutants, such as hydrocarbons or heavy metals, than are normally found in urban runoff. These areas merit special management and the use of specific pollution prevention activities and/or structural storm water controls. Examples of storm water hotspots include:

- Gas / fueling stations;
- Vehicle maintenance areas;

- Vehicle washing/steam cleaning;
- Auto recycling facilities;
- Outdoor material storage areas;
- Loading and transfer areas;
- Landfills;
- Construction sites;
- Industrial sites; and,
- Industrial rooftops.

Figure 1-11 shows examples of potential storm water hotspots.

Figure 1-11 Examples of Potential Storm Water Hotspots
Filling Station at Lewis and Broadway (ca 1930) and Fleet Storage Area on South Meridian Avenue during 1998 Flood

1.2 Social and Economic Impacts of Uncontrolled Storm water

The effects of urban storm water runoff are not only environmental, but also have very real social and economic impacts on the City and County. These impacts are described below.

1.2.1 Human Welfare

The first concern of local governments is that of public safety. Increased runoff peak flows and volumes due to development can potentially overwhelm storm water drainage facilities, structural controls and downstream conveyances, putting human welfare at risk. Floodwaters can cause driving hazards by overtopping roadways and washing out bridges, as well as carrying sediment and debris onto streets and highways.

Since 1877, there have been 16 “notable” flood events, two of which were presidentially declared disasters. Surface waters historically prone to flooding include: Arkansas River, Little Arkansas River, Ninnescah River, Jester Creek, Big Slough Creek, Chisholm Creek, Cowskin Creek, Dry Creek, Gypsum Creek, Wildcat Creek, Clearwater Creek, Spring Creek and Sand Creek. Areas of Sedgwick County prone to flooding are shown on the 2001 Flood Insurance Rate Map (FIRM) panels. A composite of the panels is shown in Figure 1-12, with cities displayed in green and blue, and flood prone areas displayed in gray. The October 1, 1973 flood peak was the largest on record and closely approximates the 100-year flood frequency.

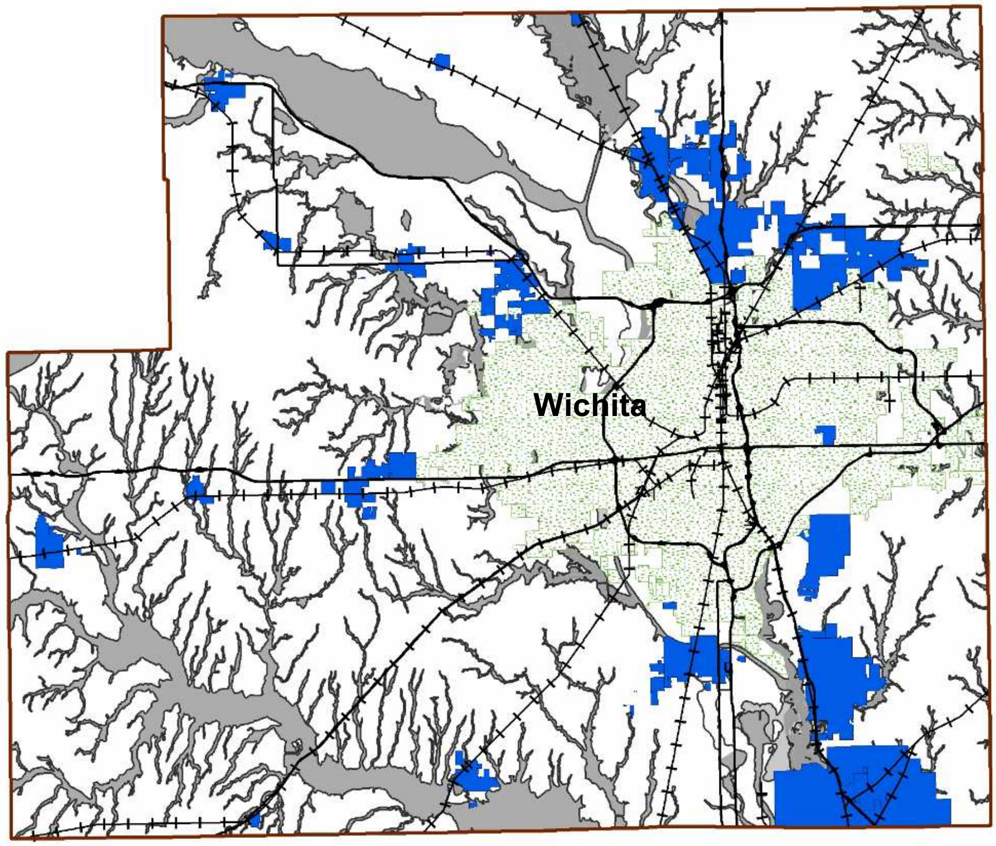

Figure 1-12 Composite of Sedgwick County Flood Panels

Floods on the Little Arkansas River exceed channel capacity on the average of once a year. The U.S. Army Corps of Engineer (USACE) Wichita and Valley Center Local Protection Project (completed in 1959) is the largest mitigation constructed to provide protection to the City of Wichita. The project comprises a system of control structures and levees and is designed to intercept the excess flow of Chisholm Creek, the Little Arkansas River, the Arkansas River, Big Slough Creek and Cowskin Creek, among other streams. The amount of investment in these flood control structures demonstrates the importance of flood protection in Wichita and Sedgwick County.

1.2.2 Property and Structural Damage Due to Flooding

Due to upstream development, properties that were previously outside the 100-year floodplain may now find themselves subject to flood damage. Areas that previously flooded only once every 10 years may flood more frequently and with more severity due to upstream development. Increased property and infrastructure damage can also result from stream channel widening, undersized runoff storage and conveyance facilities, and development in the floodplain. Figure 1-13 includes photos from two local flooding events.

Figure 1-13 Flooding Endangers Human Life and Property
Cowskin Branch during 1998 Flood and Truck Stranded on South Meridian Street during May 2006 Flood

1.2.3 Impairment of Drinking Water Supplies (Surface and Groundwater)

Water quality degradation from polluted storm water runoff can contaminate both surface and groundwater drinking water supplies and potentially make them unfit for a community's use. Sedgwick County is particularly susceptible to contamination of the drinking water aquifer due to the shallow nature of the Equus beds that local drinking water is drawn from.

1.2.4 Increased Cost of Treating Drinking Water

Even if a drinking water supply remains viable, heavy concentrations of contaminants such as sediment and bacteria can increase the costs of water treatment to a community and water customers.

1.2.5 Loss of Recreational Opportunities on Streams, Rivers, and Lakes

Turbidity from sediment, odors, floating trash, toxic pollutants and microbial contamination from storm water runoff all reduce the viability of waterbodies for recreational activities such as swimming, boating and fishing. In addition, the aesthetic loss along these waterways also reduces the experience for noncontact recreation such as picnicking, jogging, biking, camping and hunting.

1.2.6 Increased Litigation

Increased legal action can result against local governments that have not adequately addressed storm water runoff drainage and water quality problems. Communities risk lengthy and expensive court proceedings when community groups take action to force modernization of storm water policies.

1.2.7 Quality of Life

Storm water quantity and quality impacts can affect the overall quality of life in a community. The public life of Wichita is closely linked to the streams and rivers that flow through it. Examples of how residents enjoy the Little Arkansas River can be found in the yearly Riverfest and heavy use of the River Walk. Significant investment has occurred around surface water bodies within the County, so that public use and private property values are closely linked to water.

Figure 1-14 Water Quality Problems have the Potential to Impact Key Local Events like Riverfest

Many people believe that storm water pollution affects the appearance and quality of downstream waterbodies, influencing the desirability of working at, traveling to, living in, or owning property near the water.

For a number of reasons - including public health and safety, environmental, economic, legal liability, regulatory responsibility and improved quality of life - the City and County have a vested interest and need to effectively deal with the effects of development and storm water runoff. Beyond these reasons, the City and County are required by Federal and State law to implement effective local storm water regulations and guidance. The following section outlines the regulations that require local governments to control storm water, and how these regulations affect land development at the city and county level.

Figure 1-15 Waterfronts are an Important Resource for Residents and Visitors
View of the Wichita Riverwalk at Sunset

1.3 Addressing Runoff Impacts through Storm Water Management

1.3.1 The City of Wichita and Sedgwick County Storm Water Management History

Flooding problems in the 1940s and 1950s led to the creation of major flood control works to protect the city. Local flooding problems were also a concern, as streets were often swamped by storm water runoff. These local flooding problems led to the creation of design guidance on storm sewer pipe sizing and inlet design sizing. Continued flooding during the 1970s and 1980s pointed to the role of increased storm water peak flows and volumes due to urbanization. Storm water detention guidance was published in 1981 in an attempt to combat flooding due to urbanization.

The late 1980s and 1990s saw a growing recognition of urban impacts on water quality as well as water quantity. The Clean Water Act (CWA) began permitting municipalities as nonpoint dischargers under the Municipal Separate Storm Sewer System (MS4) program. Wichita was permitted in 1987, and Sedgwick County in 2004. Both of these entities have made great strides in creating overall storm water management programs to control the detrimental effects of uncontrolled storm water on local citizens and the effects land use on water quality. Figure 1-16 outlines the progress of local storm water policy.

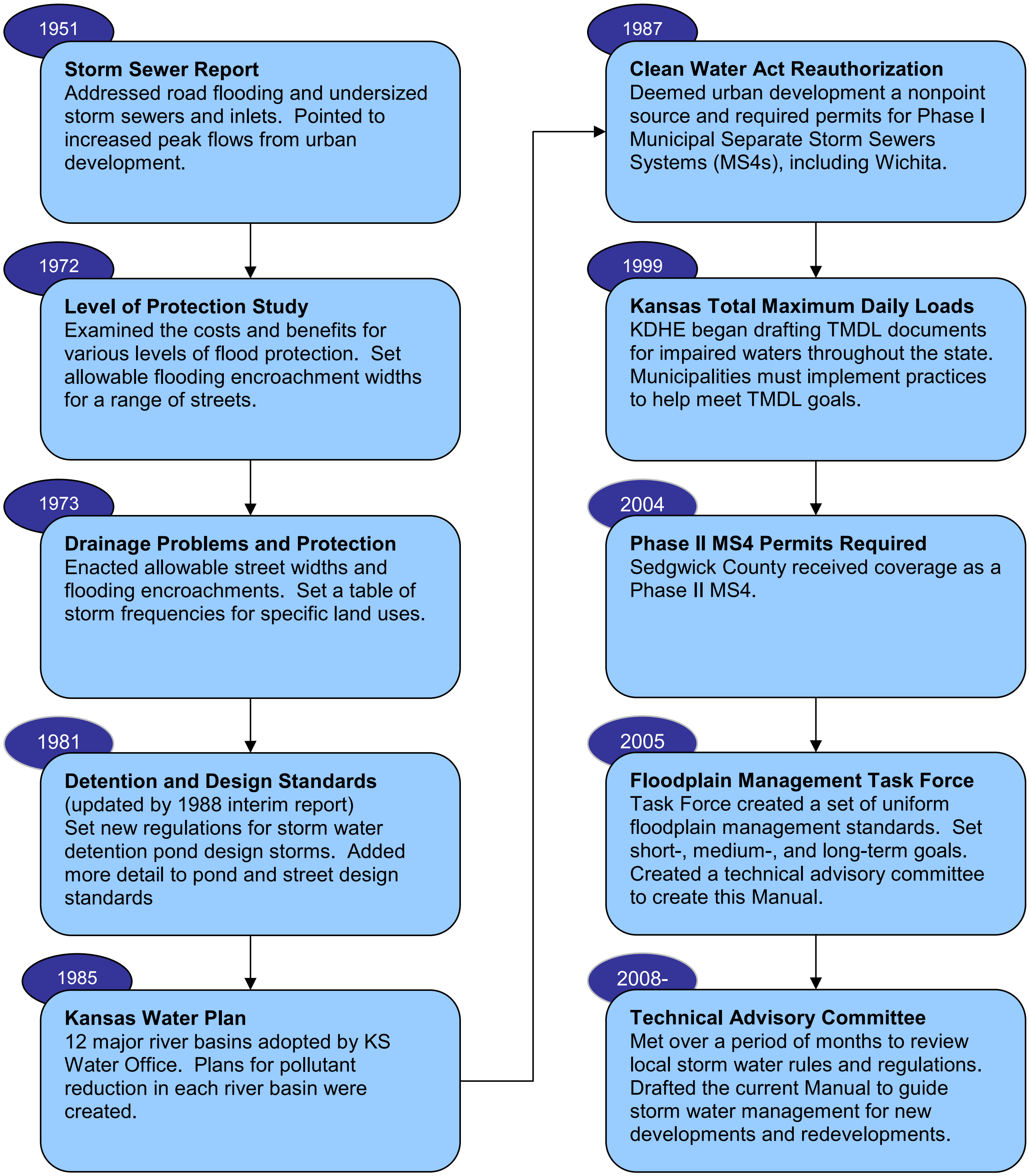

Figure 1-16 History of Policy Development

1.3.2 Moving Forward with a Comprehensive Storm Water Management Approach

Through the creation of the Storm Water Manual and associated local storm water management regulations, and the revisions to the floodplain regulations, the City of Wichita and Sedgwick County have continued to move forward with a consistent approach to deal with the impacts of development on storm water runoff.

Effective storm water management involves both the prevention and mitigation of storm water runoff quantity and quality impacts through a variety of methods and mechanisms. In general, storm water management can be broken down into the following six areas:

Watershed Planning: Using the watershed as the framework for managing land use and developing large scale solutions to regional storm water quantity and quality problems.

Development Requirements: Addressing the storm water impacts of new development and redevelopment through storm water management requirements and minimum standards.

Erosion and Sediment Control: Controlling erosion and soil loss from construction areas and resultant downstream sedimentation.

Floodplain Management: Preserving the function of floodplain areas to reduce flood hazards, minimize risks to human welfare and property, reduce modifications to streams and protect water quality.

Operations and Maintenance: Ensuring that storm water management systems and structural controls work as designed and constructed; includes the retrofitting of existing problem areas and streambank stabilization activities.

Pollution Prevention: Preventing storm water from coming into contact with contaminants and becoming polluted through a number of management measures.

Together these six categories create the “umbrella” of comprehensive storm water management as shown in Figure 1-17.

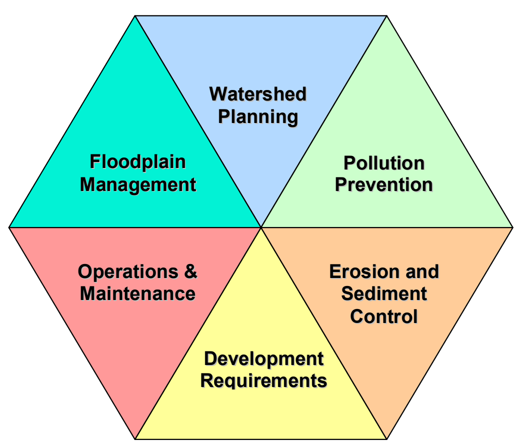

Figure 1-17
The "Umbrella" of Comprehensive Storm water Management

The focus of the Storm Water Manual is effective water quality and quantity management for new developments and redevelopments. Storm water management involves both the prevention and mitigation of storm water runoff quantity and quality impacts through a variety of methods and mechanisms.

The Storm Water Manual provides requirements, policies, and guidance for developers to effectively implement water quality management controls on-site to address the potential impacts of new development and redevelopment, and both prevent and mitigate problems associated with storm water runoff. This is accomplished by:

- Developing land in a way that minimizes its impact on a watershed by reducing both the amount of runoff and the pollutants generated (i.e., optional Preferred Site Design practices);
- Controlling storm water to prevent or reduce downstream streambank channel erosion;
- Treating storm water runoff before it is discharged to a waterway; and,
- Implementing pollution prevention practices to prevent storm water from becoming contaminated in the first place.

1.3.3 Comprehensive Storm Water Management Planning

Minimum standards and performance requirements for treating and/or controlling runoff from development are critical to addressing the impacts of urban storm water and are required of the local jurisdictions in order to comply with the National Pollutant Discharge Elimination System (NPDES) storm water regulations. Minimum storm water management standards must also be supported by a set of design and management tools and an integrated design approach for implementing both structural and nonstructural storm water facilities. The major elements of the storm water management program implemented by the City of Wichita and Sedgwick County are:

- <u>Incentives for Storm Water Preferred Site Design:</u> The first step in addressing water quality management begins with the site planning and design process. The goals of preferred site development design are to reduce the amount of runoff and pollutants that are generated from a development site and provide for some nonstructural on-site treatment and control of runoff by implementing a combination of approaches collectively known as storm water preferred site design practices. These optional (recommended but not required) practices include maximizing the protection of natural features and resources on a site, developing a site design that minimizes impact, reducing the overall site imperviousness, and utilizing natural systems for water quality management.
- <u>Water Quality Reductions for Preferred Site Design:</u> The Storm Water Manual establishes a set of optional water quality protection volume “reductions” that can be used to provide developers and site designers’ incentives to implement preferred site design practices that can reduce the volume of storm water runoff and minimize the pollutant loads from a site. While reducing storm water impacts, the reduction system can also translate directly into

cost savings to the developer by reducing the size of structural water quality management and conveyance facilities. Specific technical guidance on the water quality reductions offered is presented in Chapter 2 of Volume 2.

- Storm Water Quality Treatment: Storm water that runs off from a new development or redevelopment shall be treated to remove pollutants prior to discharge from the development or redevelopment site. Storm water management systems shall be designed to remove 80% of the post-development total suspended solids (TSS) load, based on the 85th percentile storm event, and be able to meet any other additional watershed or site-specific water quality requirements, as determined by the local jurisdiction. Design criteria and equations are presented in Chapter 3 of Volume 2. It is presumed that a storm water management system complies with this performance standard if:
  - appropriate structural storm water controls are selected, designed, constructed, and maintained according to the specific criteria in the Storm Water Manual, and
  - runoff from hotspot land uses and activities is adequately treated and addressed through the use of appropriate structural storm water controls and pollution prevention practices.
- Downstream Channel Erosion Protection: Local streams are susceptible to long-term erosion and degradation due to increased flows and flow durations resulting from upstream development and urbanization. Protection of stream channels shall be provided through the capture and extended detention of the runoff volume from the 1-year return frequency, 24-hour duration storm event. Channel protection requirements are presented in Volume 1 and Chapter 4 of Volume 2.
- Downstream Impact Analysis (e.g. the 10% rule): The potential for a new development or redevelopment to increase flooding downstream is managed by requiring a hydrologic analysis to extend from the property boundary to a point downstream where the development area is 10% or less of the total drainage area. Measures must be taken to ensure that the project does not increase flooding for the 2, 5, 10, 25 and 100-year, 24-hour rainfall events. Downstream impact analysis requirements are presented in Volume 1 and Chapter 4 of Volume 2.
- Guidance on Structural Storm Water Management Facilities: Volume 2 of the Manual provides requirements and specifications for a set of structural water quality management facilities that can be used to meet the water quality and flood control management goals.

1.3.4 Summary of Integrated Site Design

The design criteria and specifications in the Storm Water Manual communicate the regional approach to address potential adverse impacts of storm water runoff for new developments and redevelopments. The purpose of the design criteria is to provide a framework for design of a development site's storm water management system in order to reduce storm water runoff pollutants; control peak flows, runoff volumes and velocities, and prevent long-term downstream streambank and channel erosion.

Volume 2 of the Manual presents the Integrated Site Design (ISD) approach to site-level storm water management. The ISD approach takes advantage of the fact that the design criteria for water quality, channel protection, and storm water quantity can often be blended together. This enables the sizing and design of structural storm water facilities in conjunction with each other to address the overall storm water impacts from a development site. When storm water design criteria are considered as a set, the site designer can control the range of design events, from the smallest amounts of runoff that are treated for water quality, to events requiring extreme flood protection, such as the 100-year storm. Figure 1-18 graphically illustrates the relative volume requirements of the various storm water controls and demonstrates that, in some cases, the controls can be nested within one-another (i.e., the flood protection volume requirement also contains the channel protection volume and the water quality treatment volume).

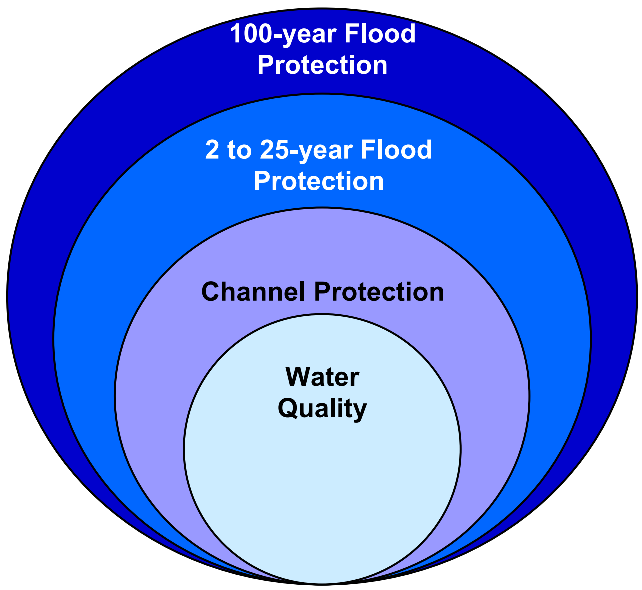

Figure 1-18 Design Volume "Nesting" of Storm water Criteria

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